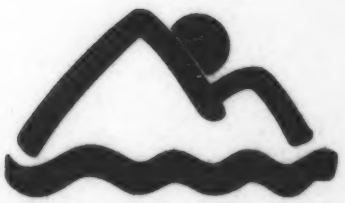
BC Environment

Procedural Manual for Municipal Solid Waste Composition Analysis



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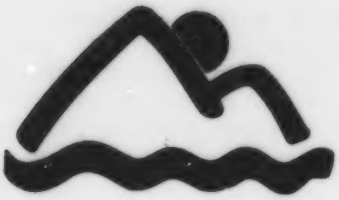

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Procedural Manual for Municipal Solid Waste Composition Analysis

Municipal Solid and
Biomedical Waste Branch
Environmental Protection Division
Ministry of Environment, Lands and Parks
November 1991

Prepared by:
Gartner Lee Ltd.

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Foreward

The Municipal Solid and Biomedical Waste Branch of the Ministry of Environment is charged with the implementation of the the Municipal Solid Waste Management Strategy of the Provincial Government. The Branch coordinates the various efforts of governments, the public, industry and business as they work together toward the provincial goal of a 50 percent reduction in the per capita generation of solid waste by the year 2000.

One of the most important elements of the Strategy is the solid waste management plans by regional districts required under Section 16.1 of the Waste Management Act. Many of the initiatives undertaken by the Branch are intended to provide assistance and guidance to regional districts in their planning efforts.

The "Guide to the Preparation of Solid Waste Management Plans by Regional Districts" stress the importance of determining the composition of the regional solid waste stream as a necessary first step in devising strategies for reducing that waste stream. The "Requirements for Regional Solid Waste Management Plans" call for updating this information every five years.

To assist regional districts in carrying out this task, the Ministry retained the firm of Gartner Lee Limited to devise a common procedure for determining waste composition and to apply that procedure to four community waste streams. This document describes the procedural manual that was developed, while companion documents include a summary description of the results of the four waste composition studies and a technical report on the methodology used.

R.J. Driedger, P.Eng.
Director, Municipal
Solid & Biomedical Waste

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1.0 INTRODUCTION TO COMPOSITION STUDIES

1.1 BACKGROUND

Little is known about municipal solid waste (MSW) stream composition in B.C. The most frequently quoted data for B.C. was obtained during a study of Canadian communities over 100,000 from 1976 to 1977 (Bird and Hale, 1979). Due to changes in packaging, technology, lifestyle, attitude and disposable income since 1977, there is a need for up-to-date data for both urban and rural communities in B.C.

In October 1990, the British Columbia Ministry of Environment retained the services of Gartner Lee Limited to develop this manual which outlines in detail the steps to follow to organize and conduct a composition survey of the residential, commercial, and institutional waste entering a municipal disposal facility. Industrial and bio-medical waste is not included in this survey.

The composition of MSW being disposed of by four communities in B.C. was estimated to develop and test methods outlined in this procedural manual. The communities involved in the composition analysis were:

1) Kamloops:
   - an urban area with mixed residential and commercial wastes with minimal source separation/recycling programs in place;

2) Maple Ridge:
   - an urban area with separate collections of residential and commercial waste, with a well established source separation/recycling program in place;

3) Castlegar:
   - a small community generating mostly residential wastes; and

4) Lower Slocan Valley:

- rural residential waste from three electoral areas of the Regional District of Central Kootenay.

Results of the application of testing methods outlined in the Manual and of the composition analysis are presented in a separate report (Gartner Lee Limited, 1991).

1.2 PURPOSE

Knowledge of waste composition enables local B.C. governments to develop new management strategies to reduce, reuse, recycle and recover waste, as well as to manage residuals.

Composition studies carried out regularly also facilitate the monitoring of local government's contribution to achieving the Provincial goal of 50% reduction in weight of waste disposed to landfills by the year 2000.

This manual describes in detail the steps to follow to estimate the composition of the residential and commercial/institutional components of a community's waste stream. These procedures were designed to obtain the greatest amount of information from the least amount of work. Following this manual will ensure that the data obtained is useful and consistent across B.C.

2.0 DESIGN OF THE WASTE COMPOSITION SURVEY

Despite countless attempts at estimating the composition of waste, there is no generally accepted or standardized method. Since it is not practical to sort through all waste that enters a disposal facility, a method of obtaining representative samples of the waste is necessary before composition analysis can begin. It is difficult to establish a methodology for waste entering a disposal site since it depends heavily on the available resources (availability of a weigh scale, budget, etc.) and on the amount of waste entering the site. The methodology presented can be adapted to the resources available for varying degrees of confidence on the resulting data.

A common misconception about waste composition is that exact values need to be determined. The composition of waste varies with the day of the week, time of the year and area of collection. Knowing the exact contents of one waste collection vehicle has limited value since it is unreasonable to expect all trucks to contain the same waste, or even to expect the same truck collecting from the same area to contain the same waste the next time that it collects. Therefore, it is valuable to not only estimate the composition of waste, but also its variability.

2.1 SURVEY AREA

Before a waste survey can be planned, the study area should be clearly defined and understood. A study area usually corresponds to the area that the city or municipality services. The different industries that exist in the study area can greatly affect the waste generated.

Information about the waste management practices of the area should be obtained. Knowledge of the amount of waste generated according to residential, and commercial/institutional sources, the number of waste collection vehicles, their schedules and routes and the number of self-haul vehicles of residential and commercial waste aid in the design of the waste survey.

2.2 DISPOSAL SITE VS. AT SOURCE SURVEY

When designing a waste survey, one issue to address is whether to obtain the wastes at the disposal site as they arrive on vehicles, or to orchestrate the collection of wastes from their source. Although the collection of wastes from their source enables the survey to be specific with its choice of waste, it is not preferred.

The advantages of performing the survey at the disposal site are:

- there is a better appreciation of the wastes entering the site from the survey area so it is less likely that the survey will overlook part of the waste stream;
- the moisture contents are those which exist after the wastes have been mixed and compacted during storage and collection;
- the mixing that occurs during collection is favourable for composition analysis;
- a better estimate of large and bulky items which occur infrequently is obtained;
- it is more cost effective to focus resources on the analysis of wastes at the disposal site then to orchestrate the collection of wastes from their sources.

2.3 WASTE STREAM

The total waste stream is divided into waste collected by waste collection vehicles and waste hauled in on self-haul vehicles. These specific waste streams are studied separately since they are usually very different. Waste collected by collection vehicles can be solely residential, solely commercial or a mixture of many sources. Waste disposed of by private haulers is often predominantly one type; construction and demolition debris, or yard waste for instance. The compositions of these waste streams

are estimated separately. The composition of the total waste stream is then estimated with the proportion that each contributes.

The sub-waste streams are further sub-divided into residential and commercial/institutional sources where appropriate. Residential refers to homes receiving door-to-door pick-up. Wastes from apartment buildings are stored in bins and collected on vehicles which also collect from commercial/institutional sources such as restaurants, motels, gas stations, stores and schools. Doctors, dentists and veterinary offices are also serviced and can be a source of dangerous hypodermic needles, among other things.

When designing the waste survey, it is important to consider the total waste stream. White goods and automobiles are often not disposed at the site as these may have special collections and special disposal sites. It should be clearly stated at the outset what the goals of the survey are and any exclusions should be reported with the data. One should be aware of all special collections. These are common for Christmas trees, household hazardous wastes, yard wastes, and bulky goods.

Only a survey of residential and commercial/institutional wastes is considered in this manual. This manual does not attempt to study industrial wastes. Hazardous bio-medical wastes generated by hospitals or clinics are usually incinerated but can occasionally make their way to the municipal disposal facility.

2.3 SIZE AND NUMBER OF SAMPLES

The goal in composition analysis is to provide an estimate of the percentage composition of each sorted category with some confidence interval about that estimate. To improve the confidence interval, the variation about the estimate must be reduced by either reducing the variation of the components or by increasing the number of samples to sort. Increasing the size of the sample for analysis reduces the variation of the components. This means that in a 600 lb sample, the sorted components will have less variation than in a 200 lb sample. Unfortunately, given a limited amount of resources, increasing the size of the sample means reducing the number of samples that

can be sorted. Generally, the greater the number of samples, the better the samples can represent the waste stream to capture temporal and demographic variations in the composition.

There have been several studies on the optimal size to sample from a refuse truck (Klee and Carruth, 1970; Britton, 1972; Lohani and Ko, 1988). These studies were designed for separation into only ten categories, and recommend using 91 kg (200 lb) samples. For this survey, which separates into more than thirty categories, a 136 kg (300 lb) sample is recommended. Therefore, a sample of 136 kg is taken from the load or pile whose composition is to be estimated. For waste collection vehicles, a sample is taken from each selected load after the large items have been pulled out and weighed. For self-haul vehicles, a sample is taken from a pile which is created from the items that are not readily identified and weighed while the selected vehicles are unloaded.

The number of samples to take, confusingly known as the sample size, can be calculated through a method proposed by Klee (1980). It is calculated using the expected percentage of each component, the expected standard deviations of the components in the chosen sized sample, and the desired precision and confidence of the results. Precision is a measure of the closeness of repeated sample values. Precision is usually presented as a percentage of the expected value of each component.

Figure 2.1, an example graph which aids in the selection of the number of samples to sort for composition analysis, was adapted for a residential waste stream serviced by collection vehicles using composition data from a specific study area in B.C. during the methods testing phase of this study. This graph was adapted from Woodyard and Klee (1978) using Klee's sample size analysis. The values used for expected compositions of the study area, and the standard deviations for within-week variation of raw solid waste components for 136 kg samples are presented in Table 2.1.

FIGURE 2.1 NUMBER OF RESIDENTIAL WASTE COLLECTION VEHICLES FROM A SPECIFIC STUDY AREA REQUIRED TO CONTRIBUTE A 136 KG SAMPLE FOR COMPOSITION ANALYSIS WITH 90% CONFIDENCE (MODIFIED AFTER WOODYARD AND KLEE, 1978)

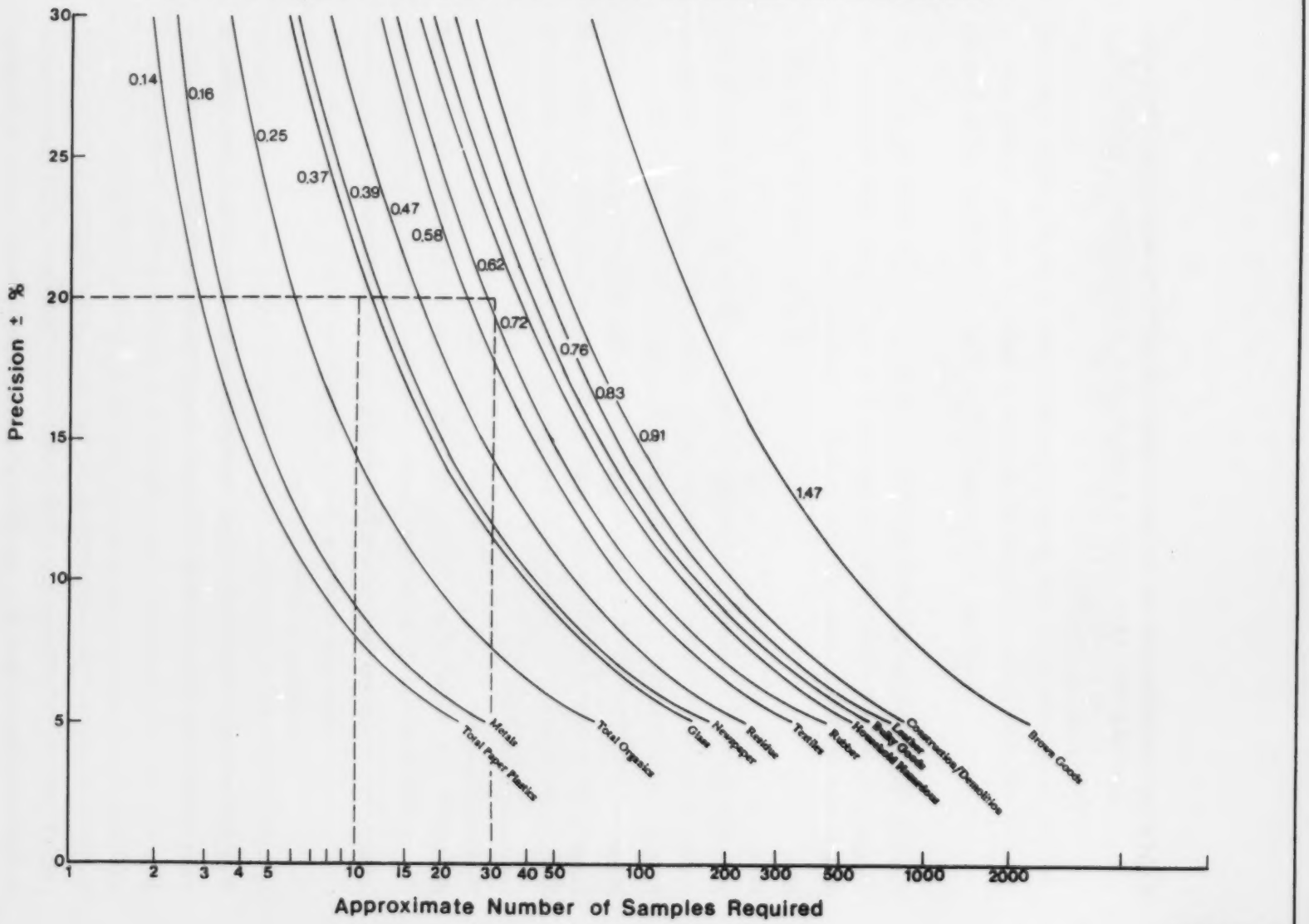

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TABLE 2.1 ESTIMATED MUNICIPAL SOLID WASTE CHARACTERISTICS OF RESIDENTIAL WASTE STREAM FOR ANALYZING NUMBER OF 136 kg SAMPLES TO SORT IN SPECIFIC STUDY AREA IN B.C. (Gartner Lee, 1991)

	x^1 (%)	Sx^2 (%)	Cov[3]
Total Paper including Newspaper	40.2	5.6	0.14
Newspaper	10.2	4.0	0.39
Plastics	8.9	1.4	0.14
Glass	9.5	3.5	0.37
Metals	6.6	1.0	0.16
Total Organics	20.2	5.0	0.25
Textiles	2.8	1.6	0.58
Leather	0.9	0.8	0.83
Rubber	0.3	0.2	0.62
Brown Goods	0.6	0.9	1.47
Bulky Goods	0.9	0.7	0.76
Construction/Demolition	2.3	2.1	0.91
Household Hazardous	2.4	1.8	0.72
Residue	3.4	1.6	0.47

notes:
[1] expected composition of Residential waste on a dry weight basis
[2] within-week variation of 136 kg samples on dry weight basis
[3] coefficient of variation = $(^{Sx}/_{x})$

It should be recognized that this graph was developed from results from the residential waste stream from a specific study area and will be different for waste streams with different waste characteristics. Also, it should be recognized that the graph is representative of autumn waste characteristics for the specific study area.

From Figure 2.1, the greatest gains in precision occur when the number of samples analyzed is relatively low. For example, the precision improves from 30 to 20% for total paper products by increasing the number of samples analyzed from two to three.

Generally, an unrealistic number of samples is needed to estimate those components that are bulky and not frequently found. Figure 2.1 shows that to obtain estimates of brown goods, construction/demolition debris, leather, bulky goods and household hazardous goods to within ± 20% of their true values, over 30 samples would require analysis during a one-week period. Not only is 30 samples unmanageable, but in the cases of smaller communities, it is not possible to obtain that many.

The curves for large objects (i.e., bulky goods, construction/demolition debris, etc.) are based on such objects being separated from the collection vehicle prior to obtaining the 136 kg sample for sorting. They are weighed to establish their percentage contribution to the entire load as discussed in Section 4.0.

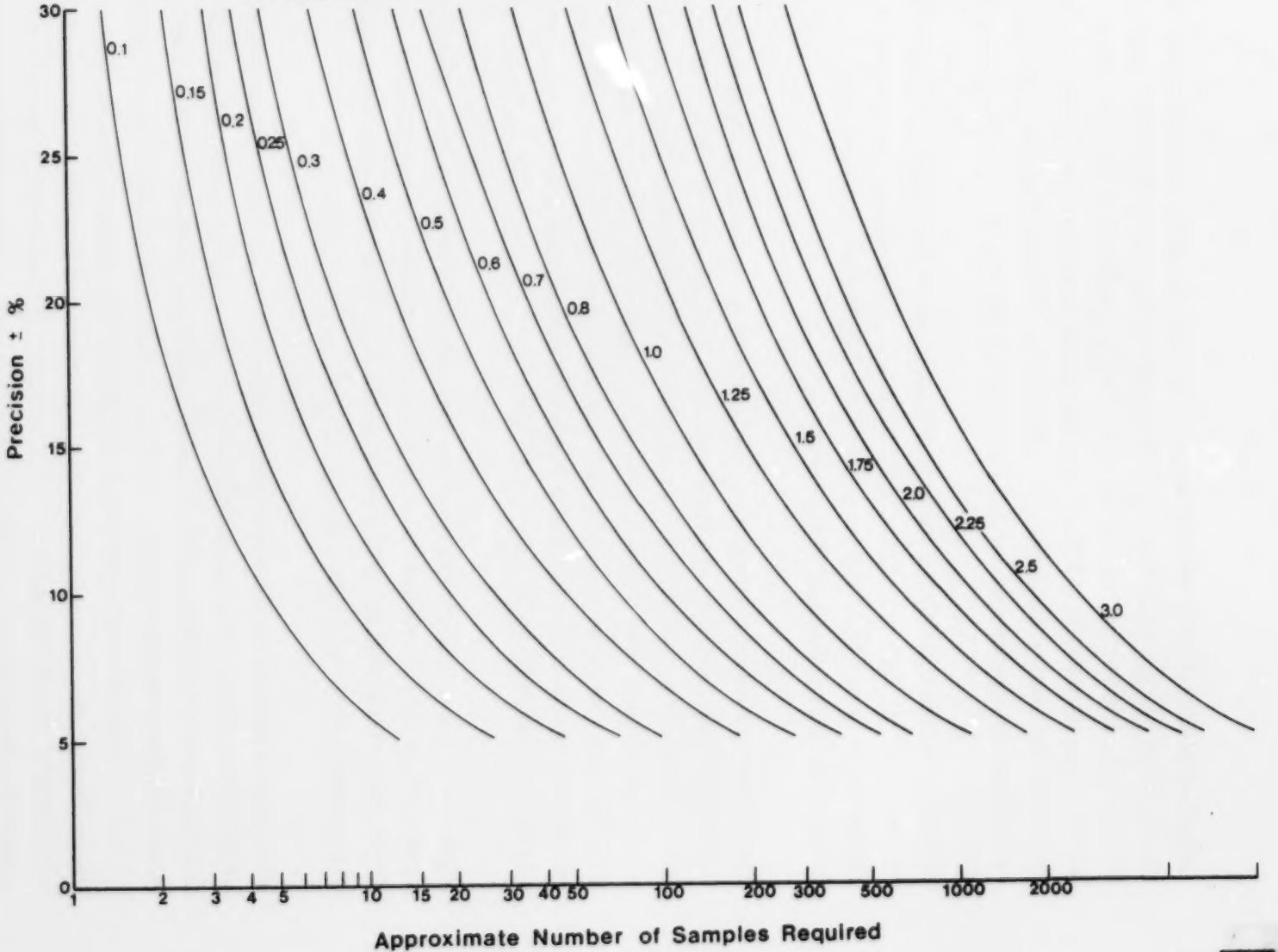
The number of samples to take depends on the resources available for the survey and the desired confidence of the results. From experience, it is expected that it will take two people a full day to obtain and sort one sample of 136 kg. Therefore, in a one-week survey, two people should be able to analyze five samples. If ten samples are analyzed from this study area, total paper products, and metals should be known to within ±10% of their true values, total organics to within ±15% glass and newspaper to within ±25% and residue to within ±30%.

Figure 2.2 is a generic graph for estimating the number of samples to take. When the characteristics of the waste stream are available, from estimates or a preliminary survey, the survey can be designed using the coefficient of variation of the components of the waste stream.

When determining the number of samples to take, each waste stream studied should be considered separately. The number of samples to take from waste collection vehicles and self-haul vehicles is considered separately as is the number from residential and commercial/institutional sources.

The number of samples to take from each waste stream also depends on the size of the waste streams. It makes sense to use more of the available resources getting a better estimate of a larger proportion of the total waste stream. It is also possible to have greater interest in one of the waste streams. For example, if the main goal of the

FIGURE 2.2 NUMBER OF 136 KG SAMPLES OF COMPONENTS WITH COEFFICIENT OF VARIATION VALUES 0.1 - 3.0 TO ACHIEVE THE DESIRED PRECISION WITH 90% CONFIDENCE



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composition survey is to determine the amount of recyclables present for a blue box program, the target waste stream, usually residential serviced by collection vehicles, should be studied.

2.4 COMPOSITIONS

A detailed list of the waste components that the Ministry of Environment may request for the waste composition survey is presented in Table 2.2. This list was designed to address many issues. Glass and aluminum beverage containers are separated into refundable and non-refundable to provide information on the effectiveness of refund policy. Detailed categories exist to determine amounts of recyclables and compostables present in the waste stream. Also, knowledge of the amounts of inerts in the waste stream can be beneficial if incineration is considered as a disposal option.

It may not be necessary to consider every waste category presented in Table 2.2. The choice of which categories to separate for depends on the ultimate use of the data. While designing a composition analysis, the need for and uses of the data should be clearly established. For example, when separating refundable from non-refundable, it should be clear whether to include items which are refundable elsewhere. Also, the category for polyethylene (PET) beverage containers should be specific whether to include liquor bottles or if only the refundable types are of interest. If only the refundable types are considered, it should be further specified whether to include those which have already been refunded and have been discarded by the supermarket.

When an item could potentially fall into several categories, it should be clear which category has priority. For multi-material combinations, the item was put into the category which made up the greatest proportion of the item by weight. For example, aluminized plastic chip bags were put in multi-material plastic, meat soaks were under multi-material paper and frozen juice cans (made of cardboard with metal tops) were classified under multi-material metals.

2.5 SURVEY SCHEDULE

Wastes are studied as they arrive at the disposal facility during single week surveys. Wastes should be studied throughout the year since they vary considerably. To obtain a yearly estimate of the composition of the wastes, these single week surveys should be repeated on a seasonal basis to capture some of the seasonal variation of the waste.

TABLE 2.2 DETAILED LIST OF CATEGORIES FOR COMPOSITION ANALYSIS

•	PAPER	- newspaper, including non-glossy magazines and flyers, - corrugated cardboard and brown paper bags, - fine/ledger paper, including bond and computer, - glossy magazines and fliers - telephone books, books - packing paper-food boxes and trays, tubes, containers, waxed paper, etc., - tetra pak beverage containers, - non-packaging paper, including towels, napkins, and mail not elsewhere classified (n.e.c.), - other paper, including multi-material combinations such as bubble packs, meat soaks, carbon or blue print paper, and window envelopes, and - contaminated paper, including disposable diapers and sanitary napkins;
•	GLASS	- beverage containers, refundable, - beverage containers, non-refundable, - food and other containers, - other glass, including mirrors, plate, pyrex and multi-material combinations such as light bulbs;
•	METAL	- aluminum beverage containers, refundable, - aluminum beverage containers, non-refundable, - other aluminum including foil, tins and cookwear, - steel beverage containers, - other steel cans, - other ferrous, including banding and machine parts, - non-ferrous (copper, brass, lead, etc.), and - other metal, including multi-material combinations;
•	PLASTIC	- Polyethylene terephthalate (PET) beverage containers, code 1* - other PET, - High Density Polyethylene (HDPE) - all colours, code 2* - Low Density Polyethylene (LDPE), code 4* - Polyvinyl Chloride (PVC), code 3* - Polystyrene (PS), code 6* - Polypropylene (PP), code 5* - other plastics, code 7*, Saran Wrap, acryl butyl styren (ABS), and - multi-resin materials, such as laminates, and multi-material combinations, such as packaging n.e.c.;
•	ORGANIC	- kitchen and restaurant waste, according to animal or vegetable origin, - yard waste (grass, leaves, cuttings and stalks), land clearing or landscaping debris, including brush, trees, large tree limbs and stumps, - other wood, including pallets, scrap lumber and boxes, and - food and agricultural processing waste;

* *from the plastic industry's voluntary coding system*

- **TEXTILES**
  - natural fibre,
  - synthetic fibre;
- **LEATHER** – including foot wear with multi-material combinations;
- **RUBBER**
  - used tires,
  - other rubber products (including foam rubber);
- **WHITE GOODS** – including refrigerators, stoves, etc.;
- **BULKY GOODS** – including office and household furniture;
- **BROWN GOODS** – including electrical and electronic appliances and toys;
- **CONSTRUCTION & DEMOLITION DEBRIS**
  - gyproc;
  - inerts including concrete, asphalt, bricks, rocks, and dirt;
  - insulation, preserved lumber, and other matierals n.e.c.;
- **RESIDUE** – including ash, ceramics and fines
- **HOUSEHOLD HAZARDOUS** – including the following categories of materials and the containers or appliances in which they were sold:
  - automotive supplies, including oil, and other products,
  - painting and decorating supplies,
  - building and woodworking supplies,
  - garden, pool and septic tank supplies,
  - pet and hobby supplies,
  - housecleaning and laundry supplies,
  - medical supplies, and
  - Lead acid batteries
  - dry cell batteries, by type, (alkaline, mercury, nickel-cadmium, lithium) and including batteries which cannot easily be removed from the appliance in which they were purchased,
  - aerosol,
  - cosmetic, personal products;
- **OTHER MATERIALS**, n.e.c.;

3.0 ORGANIZING THE WASTE SURVEY

After designing the purpose and goals, the steps involved in organizing the waste composition study are as follows:

- find a suitable site,
- arrange to weigh the vehicles entering the site,
- hire and train the staff,
- arrange for a laboratory to analyze the moisture contents of the wastes in each category,
- buy the necessary equipment and supplies,
- prepare standardized data forms.

Each of these tasks is described in detail below.

3.1 SITE REQUIREMENTS

There are some critical requirements of a waste disposal or transfer site for this waste composition analysis. Firstly, there should be a covered area where waste sorting tables, buckets and scales can be set up. The equipment storage shed at a landfill site serves the purpose quite adequately; however, if the area is not heated, the sorting of wastes becomes impractical during sub-zero weather. The sorting area can be some distance from the landfill face, although this requires that some means of transporting the waste samples be arranged.

Secondly, there should be room to spread the loads dumped by waste collection vehicles and pull out large objects. Space limitations can be experienced during busy periods, especially in a transfer station. When space is restricted, only one load can be spread at a time and must be dealt with as quickly as possible. Good communication is essential with both the site operators and the waste collectors in order to avoid traffic congestion at the site.

Finally, space is required to survey the self-haul waste stream. A special area should be designated for vehicles chosen to be surveyed. While the chosen vehicles unload their waste, large and readily identifiable objects should be quickly weighed before they are disposed of in the usual manner. A storage area is required for the remainder of the

waste. Two piles will accumulate, one for residential wastes, the other for commercial wastes. These piles will be sampled as described in Section 4.4 to estimate their compositions.

3.2 WEIGH SCALE

Not all MSW facilities in B.C. are equipped with a weigh scale. The owners of waste disposal sites should recognize the value of their site disposal capacity. Disposal fees at many places in North America have become well over $100.00 per tonne. It is expected that the disposal fees in the lower mainland of B.C. will reach $100.00 per tonne in the near future. Site owners should seriously consider the installation of a weigh scale or an additional scale for weigh out in order to protect their assets. It has been known that landfills without disposal fees per weight tend to attract waste from outside the service area. It would be ideal to weigh all waste hauling vehicles including self-haul vehicles during the waste sampling period.

If a weigh scale is not present at the disposal site, vehicles might be diverted to the nearest scale operated by the Ministry of Transportation and Highways or private industry (e.g. cement plant, gravel pit, etc.). Diverting vehicles to a Ministry of Transportation and Highways weigh scale may be a difficult undertaking. Vehicles not already required to stop may not be willing to do so for fear of being charged if their vehicle does not meet the safety inspection.

Alternately, a portable scale can be rented and placed at the entrance of the site. Scales can be rented through construction contractors.

If the weighing of self-haul vehicles is impractical, the quantity of waste generated can be estimated by having them unload their waste into bins that can be weighed during the sampling periods. The size of the bin to use should be determined on the basis of the estimated daily waste volume. At least two bins should be placed at the site so that one bin is available while the other is being weighed. Depending on the size of the bins, an access ramp should be constructed for the safety and convenience of the waste haulers.

3.3 STAFFING REQUIREMENTS

The size of the waste survey team depends on the resources available, the desired accuracy of the data and the size of the waste stream.

There should be a person in charge of the survey of waste collection vehicles who oversees the scheduling and the communications with the waste haulers and site operators. That same person should take notes and record data.

A second person should head up the survey of the self-haul waste stream. This person's duties include choosing which vehicles to sample, explaining the survey to the waste haulers, orchestrating the weighing of large and easily identifiable objects, and recording all weights.

The remainder of the survey team has many responsibilities that they can either share or specialize in. For the survey of waste collection vehicles, they must separate and weigh large objects from each load studied. A 136 kg (300 lb) sample must be obtained from each load and brought to the waste sorting area.

Similarly, for the survey of self-haul wastes, the weights of easily identifiable objects on the vehicles must be estimated. The remaining waste is collected into separate piles of residential and commercial waste that are not readily identified. Samples of 136 kg must be obtained from these piles to estimate their composition.

Finally, the 136 kg samples must be sorted into the various waste categories. The categories must be weighed and samples for moisture content analysis must be obtained. One waste sorter should specialize in the sorting of plastics and metals. It is best to designate this job to one person since it takes considerable time to learn to identify the different types of plastics.

It is recommended to hire people who have prior interest in waste management. This is a very physically demanding job, one which can destroy anyone's appetite. Not only is the work very demanding but it requires that the team be committed to the study.

A minimum of seven people is recommended for the survey team. The team should consist of one person in charge of the collection vehicle survey as described above, two

to survey the self-haul waste stream, two to separate and weigh large objects from the waste collection vehicles and two to sort the 136 kg waste samples. This team should be able to analyze twelve to fifteen 136 kg samples in a one-week period.

3.4 STAFF TRAINING

Before the waste survey begins, the waste sorters should be familiar with their duties. The survey will run more smoothly if the team understands the purpose of their job.

Sorting through garbage can be very dangerous. It is important that the survey team undergo safety training so that they are prepared and aware of the hazards. Nearly anything can be hidden within refuse, from toxic chemicals to unprotected syringes.

An important requirement is that workers be up-to-date on their tetanus vaccination. Hepatitis vaccinations are not essential, as garbage is not considered to be high risk exposure. Inoculation against hepatitis can take many months to be administered and can have undesirable side effects. Instead, workers should take every precaution to avoid contact with blood products. Post exposure treatment of hepatitis is available. If there is any health concern, workers should immediately consult a physician.

It is desirable that at least one person of the survey team have first aid training. To avoid infection, every cut should be promptly cleaned and bandaged. A first aid kit and fire extinguisher should accompany the workers both at the waste sorting area, and at the waste dumping site.

The workers should be equipped with proper safety attire. A list of the recommended attire is provided in Section 3.6 which discusses required equipment and supplies.

It is necessary for the survey team to behave in a professional manner at all times, especially when dealing with the public. They should respect the privacy of others by refraining from establishing the source of the refuse they are sorting. Personal items found within the refuse, such as letters, cards and photographs, should be treated with no greater interest than vegetable waste or newspaper.

3.5 MOISTURE CONTENT ANALYSIS

Knowledge of the moisture content of the waste as it arrives at the disposal facility is critical to determine the energy needed to drive off the moisture from the waste before combustion will occur if incineration is considered as a disposal alternative. It is also important for proper control of composting or digestion of the waste.

The moisture contents of the components are necessary in a composition analysis to combine or compare the percent compositions from different samples. The reason for taking samples from different socio-economic and demographic areas is to identify differences. If wet weights are not converted to "dry" or "as-generated" weights, the uncertainty about the variability of the moisture in the weights will handicap the analysis.

"Dry" weight is the weight of material when it has all of its moisture removed. "As-generated" weight is the normal wet weight of material in its natural state (i.e. as manufactured, produced, grown, etc.). The approach for calculation of "dry" or "as-generated" weights from wet "as-disposed" weights is presented in Section 5.0.

The components of the waste are contaminated by each other during the disposal and collection process. The moisture contents can be altered considerably depending on the type of collection, the time between collections and weather conditions en route. Items which are most susceptible to variation in moisture content are paper products, plastics, some metals, organics, textiles and residue. The moisture contents of metals, glass, leather, rubber, wood, some metals, white goods, bulky good, brown goods and household hazardous wastes vary so little that the moistures can be assumed from previous research. Representative moisture content estimate arising from the companion study (Gartner Lee Limited, 1991) and previous research are provided in Section 5.3.

It is not necessary to dry the total sorted sample to determine moisture contents. Samples of 100-500 grams of the more highly variable components should be taken for moisture content analysis. These samples should be oven dried at 77°C (170 °F) for 24 hours to assure complete dehydration and yet avoid undue vaporization of volatile material (Vesilind and Rimer, 1981). The moisture samples should be obtained soon after the sorted components have been weighed. Care should be taken to minimize the

moisture loss during the composition analysis. The moisture samples should be stored in heat resistant plastic bags that will serve as trays in the drying oven.

Analyzing waste samples for moisture content is not a common lab procedure. However, most labs are equipped with a drying oven and are capable of estimating the moisture contents of waste categories. Figures 3.1 and 3.2 show two types of drying ovens, one table top and the other a walk-in. The ovens used to dry samples should be ventilated outdoors since this is an odorous procedure.

When retaining a lab to perform moisture content analysis on the waste samples, the lab should be informed of the following information:

The standard procedure for obtaining the moisture contents of waste samples is to dry them in an oven at 77°C for 24 hours. The ovens need good circulation to ensure a constant temperature throughout. The following equation is used to calculate moisture content:

$$\%MC = \frac{\text{wet weight - dry weight}}{\text{wet weight - bag weight}} \times 100$$

The wet and dry weights in the above equation include the weight of the sample bag so that the moisture that transfers to the bag during transport is included in the moisture content value. The wet weight is obtained after the bag is unsealed and the seal, either tape or staples, is removed. The sample bag should be cut open and the contents spread out before being placed in the oven. There may be problems with the bag melting near the heating elements, therefore trays may be needed to shield the bags from radiation.

The table top ovens can each accommodate six samples in 7.7 cm x 12.8 cm (3" x 5" bags) while the closet-sized or walk-in type of oven can handle thirty samples or more in 21.8 cm x 28.2 cm (8½" x 11") bags. The larger the oven and the waste samples, the more reliable the moisture content result.

Once the samples have been dried and weighed they can be discarded.

FIGURE 3.1 TABLE TOP DRYING OVEN
Drying oven: counter top model

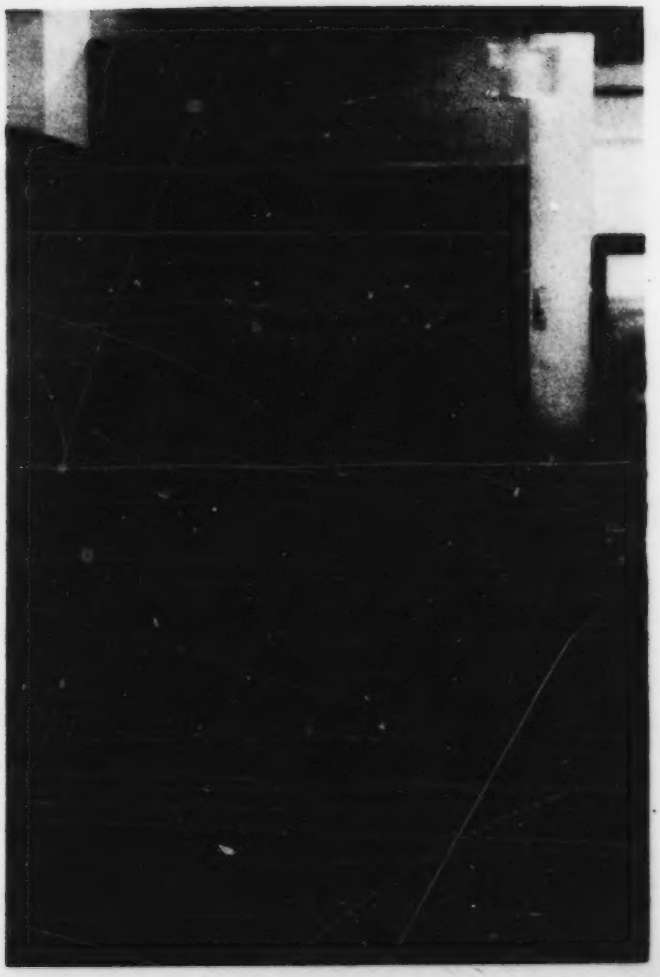


FIGURE 3.2 WALK-IN DRYING OVEN
Drying oven: sized 4' x 3' x 6'

3.6 EQUIPMENT AND SUPPLIES

The equipment and supplies needed to perform a waste composition analysis include:

Scales:

- a 50 kg platform scale to weigh large objects and samples,
- a 12 or 15 kg platform scale to weigh sorted components,
- a 2 kg platform scale to weigh sorted components and get tare weights of plastic bags or containers.

Other equipment:

- 2 tape measures for establishing sampling points on the waste pile,
- several magnets, lighters and knives for material identification,
- scissor set (garden pruning style) for cutting materials for moisture content samples,
- 3 rakes for spreading the pile,
- 1 broom for cleaning around the sorting table,
- 2 clipboards and calculator for data recording and calculations,
- 1 stapler and staples to seal moisture content bags,
- several permanent markers for labelling the moisture bags,
- camera and film,
- 2 first aid kits (one will suffice if the sorting area is close to the dumping area),
- 1 fire extinguisher,
- disinfecting soap,
- paper towels,
- antiseptic towelettes,
- water if not supplied at site for drinking and washing.

Attire for each member of the waste team:

- 2-3 pairs of protective gloves:
  - one for sample collection. These should be puncture proof and extend up the arm,
  - one for waste sorting. These should be water proof and allow reasonable dexterity,

- cotton liners for inside both sets of gloves,
- protective glasses,
- dust mask,
- cotton coveralls,
- a rubber apron,
- steel toe and shank work boots,

Supplies for each table sorting into the categories as in Table 2.2:

Garbage cans to sort into:

- 25 large sized (household type) cans,
- 25 smaller sized (office sized ~ 20-30 litres).

Plastic bags for each one-week (15 sample) survey:

- 50, 6 ml thickness clear 100 litre sized bags,
- 250 regular sized clear garbage bags to line the garbage cans,
- 250 small sized clear bags to line the smaller cans,
- 350, 6 ml bags for moisture samples sized either 7.7 cm x 12.8 cm (3" x 5") or 21.8 cm x 28.2 cm (8½" x 11"). The larger the oven and the waste samples, the more reliable the moisture content result.

Note: all bags should be clear to improve safety and avoid confusion. The bags should fit the cans snugly so that they do not droop when sorted into.

Enlargements of the waste categories (Table 2.2) and the table layout (Figure 4.2) should be readily available for reference by each sorting table.

3.7 DATA FORMS

It is important to keep consistent reliable information during the survey period, therefore, several data forms are required. A form is needed to keep information about the waste from either waste collection vehicles or self-haul vehicles chosen to contribute to the composition survey. For both the waste collection vehicles and the self-haul vehicles, information about the large or easily identified components must be recorded. Finally, a form is needed for each 136 kg sample that is analyzed for composition. Examples of these forms are presented in the following sections.

4.0 IMPLEMENTATION OF THE SURVEY

The steps to performing a waste composition survey are:

- determine the weight of the vehicle-loads servicing the survey area from each sub-waste stream studied,
- choose which vehicles will contribute waste to the composition survey,
- separate and weigh the large and easily identified items from the load,
- obtain a sample of 136 kg from a load or waste pile whose composition is to be estimated,
- sort the 136 kg sample into the desired waste categories,
- obtain samples for moisture content analysis from the sorted components.

The procedures involved in estimating the composition of waste entering the disposal site from collection and self-haul vehicles are illustrated in photos 1 to 15. These procedures are discussed in detail in the following sections.

4.1 LOAD WEIGHT

Diverting all vehicles to the nearest weigh scale may be impractical and inconvenient depending on the location and usage of the scale (Photo 1). If the weighing of all waste collection vehicles is not possible, then the weight of those loads which are not chosen for composition analysis should at least be estimated. Load weights of vehicles not included in the composition survey are used to estimate the quantities of waste disposed and the proportion of the waste stream generated by each sub-waste stream as described in Section 2.2.

If the weighing of self-haul vehicles is impractical, the quantity of waste generated by this waste stream should be estimated. One method of estimating the quantities of this waste stream is using bins as discussed in Section 3.2. If the waste stream is small enough, the weight of waste on each vehicle can be estimated while it is unloading.

It is quite common that private cars entering the MSW handling facility with a weigh scale are not weighed in order to reduce the work load of the scale operators and the length of wait. Sometimes vehicles are weighed in but not weighed out so that the weight of waste entering the site is estimated on the basis of average waste weight by

Photo 1 **The quantity of waste entering the landfill is estimated by weighing the vehicles before and after disposing their loads.**

Photo 2 **Vehicles contributing waste to the composition study are randomly chosen. These vehicles dump their waste in an area away from other activity.**

vehicle classes (eg. 200 kg for passenger cars, 300 kg for station wagons, 500 kg for pick-up trucks, etc.), or on the basis of the assumed vehicle weight. In any event, it is strongly recommended that all waste hauling vehicles should be weighed in and out during the sampling periods if an on-site scale is available.

Table 4.1 is an example of a form that can be used at the weigh scale by the operator. Every effort should be made to estimate the quantities of waste being generated since detailed knowledge of waste composition is not very useful without information about waste generation.

4.2 CHOICE OF VEHICLES TO SAMPLE

The vehicles that contribute their waste for composition-analysis should be chosen randomly. There should be no bias towards morning or afternoon nor large or small loads. The loads should come from the entire week - including weekends if possible.

The simplest method of randomly choosing vehicles is systematic sampling. This means that the number of vehicles needed for the survey are obtained from the total number entering the site by systematically choosing every *n*th vehicle where:

$$n = \frac{\text{\# of vehicles entering site}}{\text{\# of vehicles needed for the survey}}$$

Each sub-waste stream studied is considered separately when choosing the vehicles to sample.

Table 4.2 is used to record general information about the origin of the waste in each sample. The area of collection should be identified according to whether the sources are residential, or commercial/institutional. For waste collection vehicles, the time of dump, load weight, number of households in the collection, and number of bins should be recorded. As well, information on the area of collection, sources of bins and a description of the load should be recorded.

When describing the load, include an estimate of the amount of waste dumped, the previous weather conditions, obvious single sources of wastes and the efficiency of the separation of large objects.

Table 4.1 Weigh Scale Form

Date	Time	Identification		Weight In	Weight Out	Net
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			
			front rear total			

TABLE 4.2 Example Data Sheet

SAMPLE INFORMATION

SAMPLE # DATE:

Waste Collection Vehicle:

Time of Dump:

Residential Commercial Mixed
(Circle one)

Vehicle Identification:

Load Weight:

Households:

Area of Collection:

Bins:

Description of Load:

SELF-HAUL VEHICLES

Every _____ vehicle in sample

in sample:

Time start:

Time end:

Residential Commercial
(circle one)

Load weight:

Description of Waste:

For self-haul vehicles (Photo 3), the number of vehicles contributing to the load and load weight need to be recorded. The recording of licence numbers is strongly discouraged since many people find this threatening. If a weigh scale is not available, the load weight must be obtained manually. This requires that all waste from the vehicles sampled is weighed, not just the large objects as is the case when a weigh scale is available.

4.3 LARGE OR READILY IDENTIFIABLE OBJECTS

A 136 kg sample, when separated into waste categories, gives a good estimate of the amounts of papers, plastics, food wastes, and packaging materials present in the waste stream. An unreasonable number of 136 kg samples is needed to obtain a reliable estimate of the those items which are bulky or unevenly dispersed throughout the waste stream. Separating out these large or readily identifiable items from the load whose composition is being estimated, provides a better estimate of these items.

Table 4.3 is used to record the weights and descriptions of the large items separated from the pile.

Large objects can be weighed as they are unloaded from self-haul vehicles. Depending on the availability of a weigh-scale, anywhere from 30 to 100 vehicles per day can be chosen to contribute wastes for analysis for each person working with the self-haul waste stream.

It is recommended to request that loads destined for analysis be dumped away from other activity (Photo 2). In order to aid in the removal of large objects from a load from a waste collection vehicle, ask the driver to spread the load while dumping. With the cooperation of the site operators, the equipment at the disposal site can also aid in spreading the load (Photo 4). To be consistent, spread the load to 0.5-0.75 meter depths (use rakes where necessary). Separate large objects from the load and weigh them according to the waste type (see Section 2.4 for waste types)(Photo 5). Large bags should be ripped open searching for those containing wastes from one category; garden wastes or textiles, for example.

A commercial load generally has more large items to separate than a residential load. The load is ready to have a 136 kg (300 lb) sample taken when it appears to be

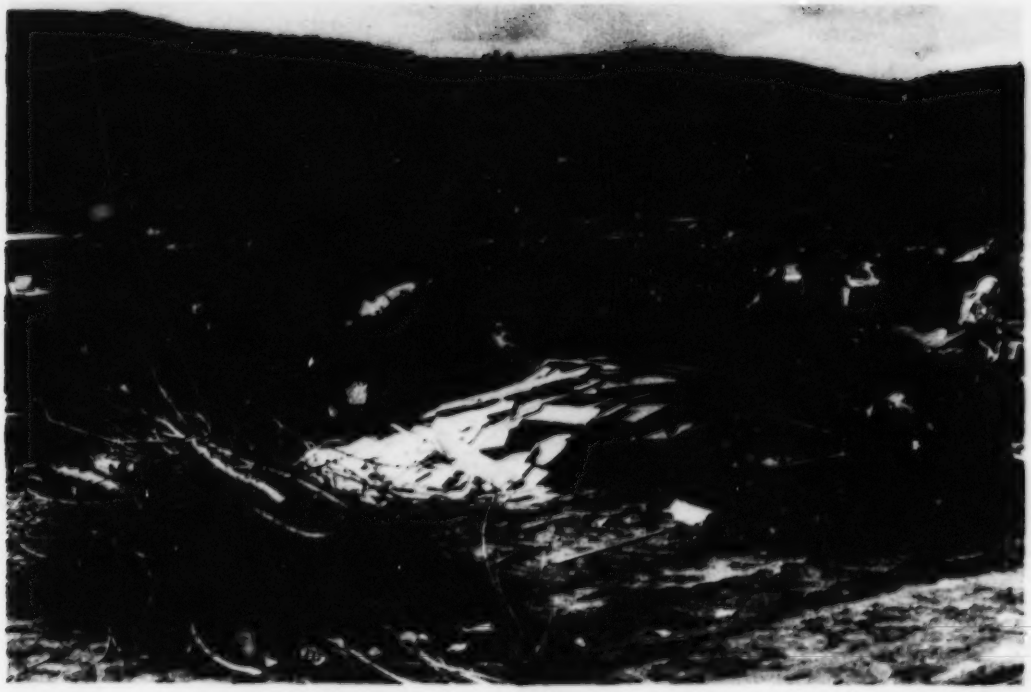


Photo 3 **This vehicle is typical of Self-Haul vehicles since it contains mostly one type of waste.**

Photo 4 **Loads dumped by waste collection vehicles are levelled to 0.5 - 0.75 m depths with the aid of the landfill operating equipment.**

Photo 5 **Large and easily identified objects are extracted and weighed.**

Photo 6 **Large objects include bags of yard wastes, carcasses, carpets, cardboard, bulky goods, etc.**

TABLE 4.3 Example Data Sheets

Large Objects: Weights and Descriptions

PAPER	
newspaper	
cardboard	
fine	
glossy magazines	
telephone books	
packaging	
tetra brik	
non–packaging	
other / multi–material	
contaminated	
GLASS	
beverage – refundable	
beverage – nonrefundable	
container	
other	
METALS	
alum. bev. –refundable	
alum. bev. – nonrefundable	
other aluminum	
steel beverage	
other steel cans	
other ferrous	
non–ferrous	
other / multi–material	
PLASTIC	
PET beverage (1)	
other PET (1)	
HDPE (2)	
LDPE (4)	
Film HDPE (2)	
Film LDPE (4)	
PVC (3)	
PS (6)	
PP (5)	
other plastics (7)	
multi–resin, multi–material	

Table 4.3 (continued)

LEATHER	
RUBBER used tires other	
ORGANIC kitchen – animal kitchen – vegetable yard waste landscaping / clearing wood food / agric. processing	
TEXTILES natural synthetic	
BROWN GOODS	
WHITE GOODS	
Construction / Demolition	
BULKY GOODS	
HOUSEHOLD HAZARDOUS automotive paint / decorating building / woodworking garden / pool / septic tank pet / hobby house cleaning / laundry medical batteries – lead acid batteries – dry cell	
OTHER	

relatively homogeneous. It takes six people approximately one hour to separate and weigh the items from an average sized residential load (a 25 yd^3 packer with 4,000 Kg). Larger commercial loads take longer.

4.4 OBTAINING THE 136 KG SAMPLE

A 136 kg (300 lb) sample is taken from both the waste collection vehicle and self-haul vehicle waste piles for detailed composition analysis (Photos 7 & 8). A sample size of 136 kg is expected to be representative of the total pile.

The 136 kg sample is taken from random locations on the waste pile. One method of obtaining random locations is to superimpose a grid made of rope on top of the pile. Figure 4.1 illustrates the flattened waste pile with the grid super-imposed on it. The grid locations are chosen using a random number table. A random number table is presented in Table 4.4.

To obtain the coordinates of the random grid locations, convert a random number to a decimal and multiply by the number of grids over the pile. For example, from Table 4.4, the number 2671 is converted to 0.2671 and multiplied by 11 since the pile is approximately 11 grid sections long. $0.2671 \times 11 = 2.2938$. To simplify, this number is truncated to 2 as the rounded off integer for the 1st coordinate. The other coordinate is $0.9111 \times 8 = 7.28$ truncated to 7. If this grid location is on the waste pile, the first bag of refuse is obtained from location (2,7). The next grid locations are calculated. They are: (0,1), (5,5), (9,0), (3,0), (7,6), (9,6), (5,4), (10,1) and (2,2). Note that some locations are not on the pile and should therefore be discarded.

This method is simplified by using two tape measures in place of the rope of the grid, since the rope grid is cumbersome. The tape measure also makes truncating the numbers unnecessary.

From each location, fill a 40 gallon bag with waste ensuring that all waste is taken from that location. If the load is dumped on a loose surface, avoid introducing this material into the sample. Take the 136 kg from 6 or 7 locations on the pile. Once taken, some notes about the load might later be useful (see Section 3.1.6). Before sorting can begin, weigh the bags to ensure that they meet the target weight of 136 kg.

Photo 7 **A 136 kg sample is obtained from random locations on the remaining waste pile. 136 kg of waste is approximately 6 or 7 large bags taken from as many locations.**

Photo 8 **It is important to take a representative sample such that it is not biased with exclusions of waste types or inclusions of foreign material.**

FIGURE 4.17 ILLUSTRATION OF A FLATTENDED WASTE PILE WITH SUPERIMPOSED GRID

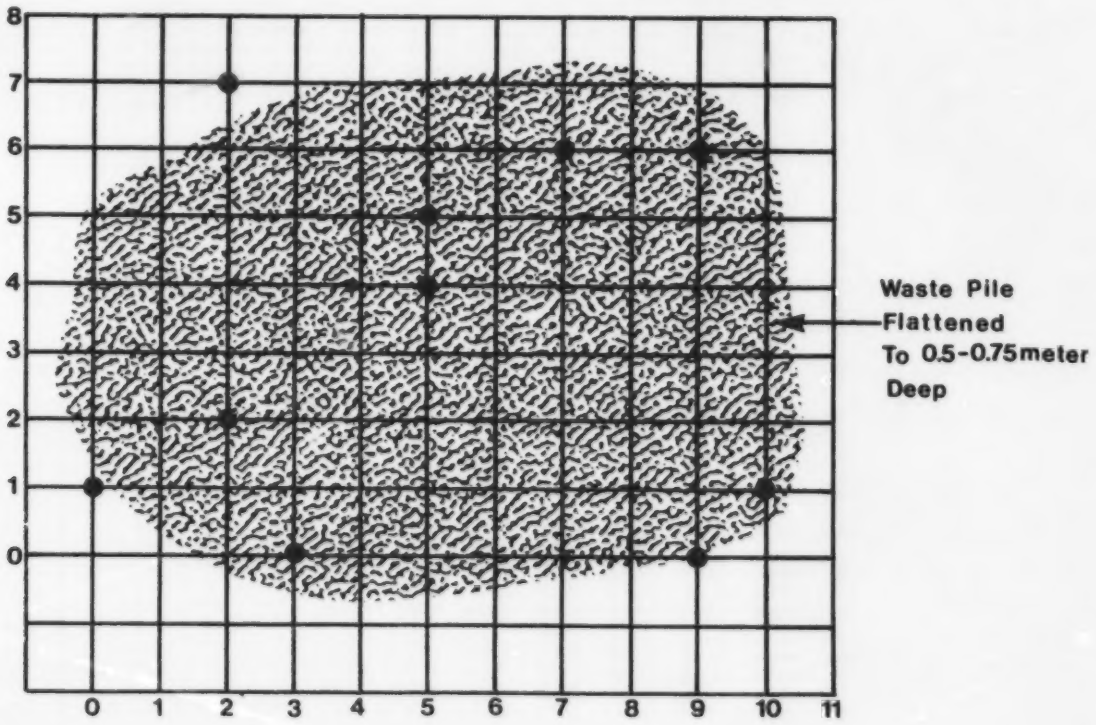


TABLE 4.4 RANDOM NUMBER TABLE

2671	4690	1550	2262	2597	8034	0785	2978	4409	0237
9111	0250	3275	7519	9740	4577	2064	0286	3398	1348
0791	6035	9230	4999	3332	0608	6113	0391	5789	9926
2475	2144	1886	2079	3004	9686	5669	4367	9306	2595
5336	5845	2095	6446	5694	3641	1085	8705	5416	9066
6808	0423	0155	1652	7897	4335	3567	7109	9690	3739
1525	0577	8940	9451	6726	0876	3818	7607	8854	3566
0398	0741	8787	3043	5063	0617	1770	5048	7721	7032
3623	9636	3638	1406	5731	3978	8068	7238	9715	3363
0739	2644	4917	8866	3632	5399	5175	7422	2476	2607
6713	3041	8133	8749	8835	6745	3597	3476	3816	3455
7775	9315	0432	8327	0861	1515	2297	3375	3713	9174
8599	2122	6842	9202	0810	2936	1514	2090	3067	3574
7955	3759	5254	1126	5553	4713	9605	7909	1658	5490
4766	0070	7260	6033	7997	0109	5993	7592	5436	1727
5165	1670	2534	8811	8231	3721	7947	5719	2640	1394
9111	0513	2751	8256	2931	7783	1281	6531	7259	6993
1667	1084	7889	8963	7018	8617	6381	0723	4926	4551
2145	4587	8585	2412	5431	4667	1942	7238	9613	2212
2739	5528	1481	7528	9368	1823	6979	2547	7268	2467
8769	5480	9160	5354	9700	1362	2774	7980	9157	8788
6531	9435	3422	2474	1475	0159	3414	5224	8399	5820
2937	4134	7120	2206	5084	9473	3958	7320	9878	8609
1581	3285	3727	8924	6204	0797	0882	5945	9375	9153
6268	1045	7076	1436	4165	0143	0293	4190	7171	7932
4293	0523	8625	1961	1039	2856	4889	4358	1492	3804
6936	4213	3212	7229	1230	0019	5998	9206	6753	3762
5334	7641	3258	3769	1362	2771	6124	9813	7915	8960
9373	1158	4418	8826	5665	5896	0358	4717	8232	4859
6968	9428	8950	5346	1741	2348	8143	5377	7695	0685
4229	0587	8794	4009	9691	4579	3302	7673	9629	5246
3807	7785	7097	5701	6639	0723	4819	0900	2713	7650
4891	8829	1642	2155	0796	0466	2946	2970	9143	6590
1055	2968	7911	7479	8199	9735	8271	5339	7058	2964
2983	2345	0568	4125	0894	8302	0506	6761	7706	4310
4026	3129	2968	8053	2797	4022	9838	9611	0975	2437
4075	0260	4256	0337	2355	9371	2954	6021	5783	2827
8488	5450	1327	7358	2034	8060	1788	6913	6123	9405
1976	1749	5742	4098	5887	4567	6064	2777	7830	5668
2793	4701	9466	9554	8294	2160	7486	1557	4769	2781
0916	6272	6925	7188	9611	1181	2301	5516	5451	6832
5961	1149	7946	1950	2010	0600	5655	0796	0569	4365
3222	4189	1891	8172	8731	4769	2782	1325	4238	9279
1176	7834	4600	9992	9449	5824	5344	1008	6678	1921
2369	8971	2314	4806	5071	8908	8274	4936	3357	4441
0041	4329	9265	0352	4764	9070	7527	7791	1094	2008
0803	8302	6814	2422	6351	0637	0514	0246	1845	8594
9965	7804	3930	8803	0268	1426	3130	3613	3947	8086
0011	2387	3148	7559	4216	2946	2865	6333	1916	2259
1767	9871	3914	5790	5287	7915	8959	1346	5482	9251

TABLE 4.4 PAGE 2

1368	9621	9151	2066	1208	2664	9822	6599	6911	5112
5953	5936	2541	4011	0408	3593	3679	1378	5936	2651
7226	9466	9553	7671	8599	2119	5337	5953	6355	6889
8883	3454	6773	8207	5576	6386	7487	0190	0867	1298
7022	5281	1168	4099	8069	8721	8353	9952	8006	9045
4576	1853	7884	2451	3488	1286	4842	7719	5795	3953
8715	1416	7028	4616	3470	9938	5703	0196	3465	0034
4011	0408	2224	7626	0643	1149	8834	6429	8691	0143
1400	3694	4482	3608	1238	8221	5129	6105	5314	8385
6370	1884	0820	4854	9161	6509	7123	4070	6759	6113
4522	5749	8084	3932	7678	3549	0051	6761	6952	7041
7195	6234	6426	7148	9945	0358	3242	0519	6550	1327
0054	0810	2937	2040	2299	4198	0846	3937	3986	1019
5166	5433	0381	9686	5670	5129	2103	1125	3404	8785
1247	3793	7415	7819	1783	0506	4878	7673	9840	6629
8529	7842	7203	1844	8619	7404	4215	9969	6948	5643
8973	3440	4366	9242	2151	0244	0922	5887	4883	1177
9307	2959	5904	9012	4951	3695	4529	7197	7179	3239
2923	4276	9467	9868	2257	1925	3382	7244	1781	8037
6372	2808	1238	8098	5509	4617	4099	6705	2386	2830
6922	1807	4900	5306	0411	1828	8634	2331	7247	3230
9862	8336	6453	0545	6127	2741	5967	8447	3017	5709
3371	1530	5104	3076	5506	3101	4143	5845	2095	6127
6712	9402	9588	7019	9248	9192	4223	6555	7947	2474
3071	8782	7157	5941	8830	8563	2252	8109	5880	9912
4022	9734	7852	9096	0051	7387	7056	9331	1317	7833
9682	8892	3577	0326	5306	0050	8517	4376	0788	5443
6705	2175	9904	3743	1902	5393	3032	8432	0612	7972
1872	8292	[illegible]366	8603	4288	6809	4357	1072	6822	5611
2559	7534	2281	7351	2064	0611	9613	2000	0327	6145
4399	3751	9783	5399	5175	8894	0296	9483	0400	2272
6074	8827	2195	2532	7680	4288	6807	3101	6850	6410
5155	7186	4722	6721	0838	3632	5355	9369	2006	7681
3193	2800	6184	7891	9838	6123	9397	4019	8389	9508
8610	1880	7423	3384	4625	6653	2900	6290	9286	2396
4778	8818	2992	6300	4239	9595	4384	0611	7687	2088
3987	1619	4164	2542	4042	7799	9084	0278	8422	4330
2977	0248	2793	3351	4922	8878	5703	7421	2054	4391
1312	2919	8220	7285	5902	7882	1403	5354	9913	7109
3890	7193	7799	9190	3275	7840	1872	6232	5295	3148
0793	3468	8762	2492	5854	8430	8472	2264	9279	2128
2139	4552	3444	6462	2524	8601	3372	1848	1472	9667
8277	9153	2880	9053	6880	4284	5044	8931	0861	1517
2236	4778	6639	0862	9509	2141	0208	1450	1222	5281
8837	7686	1771	3374	2894	7314	6856	0440	3766	6047
6605	6380	4599	3333	0713	8401	7146	8940	2629	2006
8399	8175	3525	1646	4019	8390	4344	8975	4489	3423
8053	3046	9102	4515	2944	9763	3003	3408	1199	2791
9837	9378	3237	7016	7593	5958	0068	3114	0456	6840
2557	6395	9496	1884	0612	8102	4402	5498	0422	3335

from D. B. Owen, "Handbook of Statistical Tables," Addison-Wesley, Reading, Massachusetts, 1962,

4.5 SORTING

A detailed list of the categories for composition analysis suggested by the Ministry of Environment was presented in Table 2.2. While this list may seem unmanageable for sorting, all categories can be sorted using a step-by-step method described below.

Figure 4.2 and Photos 10 and 11 show a proposed layout of the buckets around a sorting table. Note that some categories (such as kitchen wastes, film plastics, newspapers, etc.) are sorted on both sides of the table. It takes two people from three to five hours to sort the 136 kg sample depending on their efficiency and the nature of the waste being sorted.

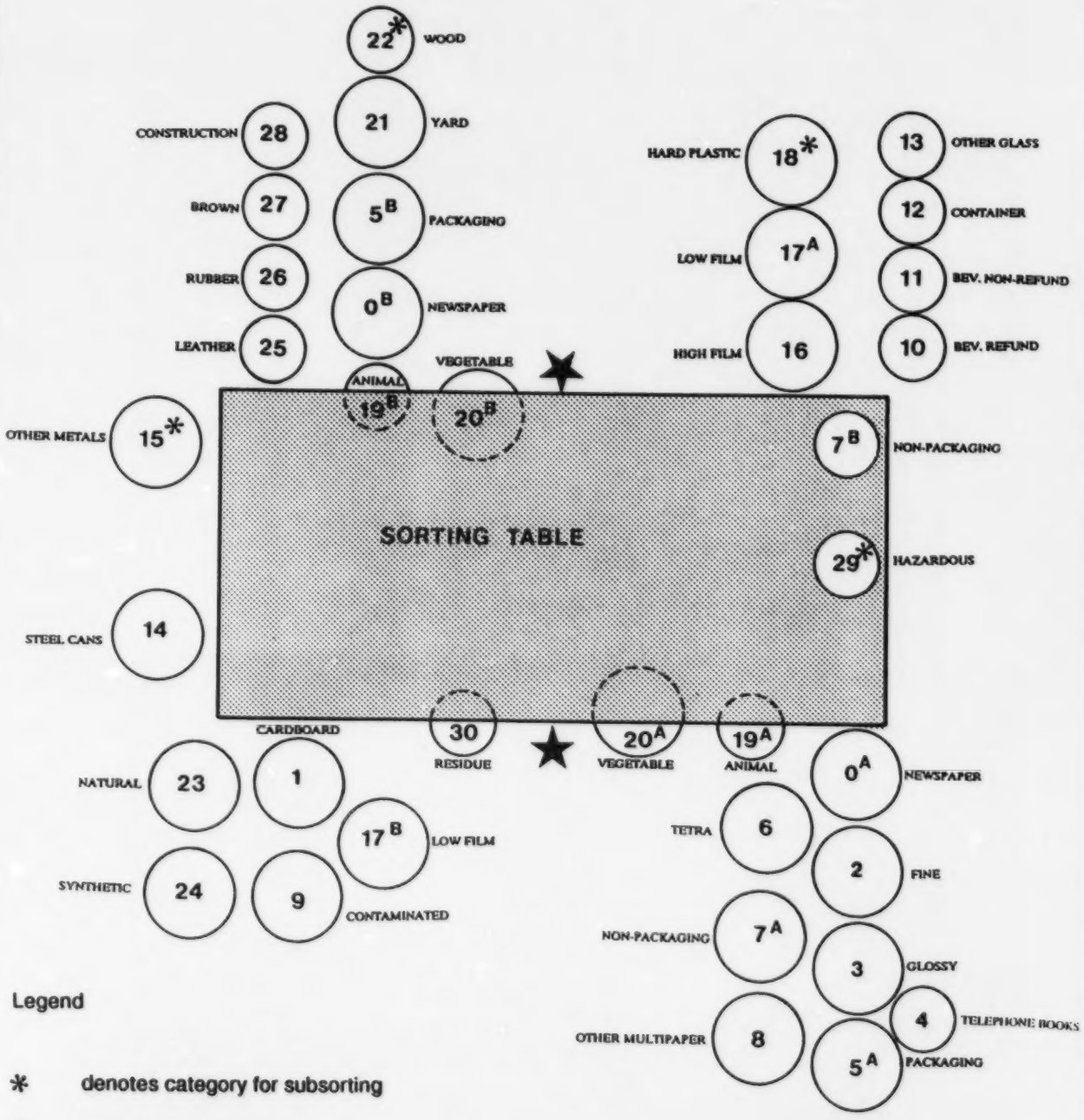
Table 4.5 shows 30 categories that are sorted during the first sort at the table.

Subsorts for metals, plastics (Photo 12), wood and household hazardous wastes are shown in Table 4.6.

Table 4.7 is used to record the weights of each waste category sorted. The weight of plastic bags used to contain the sorted components should be recorded under container weights. If a single source is responsible for most of a single waste category, that amount should be noted under comments. The weight of the load before and after sorting should be recorded on page 3 of Table 4.7. Calculating the weight loss during the sort helps to check that all waste categories were weighed. Losses of 2-3% are expected due to loss of moisture during sorting. A weight gain may occur if the climate is very humid or dusty. Moisture content sample identification numbers are recorded on Table 4.7 in the boxes before each waste category. Once the moisture data is available from the lab, it can be related to the appropriate category.

Table 4.8 contains methods to help identify plastic using water and matches. Care should be taken while burning plastics as smoke can be dangerous to inhale. High and low density polyethylene film are quite simple to identify and are therefore sorted at the table. High density polyethylene (HDPE) film is usually quite thin and crinkles when touched. Low density polyethylene (LDPE) film deforms when stretched and comes in many thicknesses. Other types of film plastics are sorted with the hard plastics.

FIGURE 4.18 LAYOUT OF SORTING TABLE



Legend

* denotes category for subsorting

★ waste sorter

2 category identification number from Table 4

1^{B} denotes multiple containers for waste category

Gartner Lee

Photo 9 **The 136 kg sample is weighed before it is sorted into its components.**

Photo 10 **The sample is sorted into different categories at the sorting table.**

Photo 11 **Waste sorters work in pairs at the sorting tables.**

Photo 12 **Plastics and metals are sorted separately.**

TABLE 4.5 CATEGORIES ACCORDING TO TABLE SORT

PAPER	(0)	newspaper
	(1)	cardboard
	(2)	fine/ledger
	(3)	glossy magazines
	(4)	telephone books
	(5)	packaging
	(6)	tetra pak
	(7)	non-packaging
	(8)	other/multi-material
	(9)	contaminated
GLASS	(10)	beverage refundable
	(11)	beverage non-refundable
	(12)	containers
	(13)	other
METALS	(14)	other steel cans
	(15)	other
PLASTIC	(16)	HDPE Film
	(17)	LDPE Film
	(18)	other
ORGANIC	(19)	kitchen/restaurant - animal origin
	(20)	kitchen/restaurant - vegetable origin
	(21)	yard waste
	(22)	wood
TEXTILES	(23)	natural
	(24)	synthetic
LEATHER	(25)	
RUBBER	(26)	
BROWN GOODS	(27)	
CONSTRUCTION/DEMOLITION DEBRIS	(28)	
HOUSEHOLD HAZARDOUS	(29)	
RESIDUE	(30)	
OTHER	(31)	

TABLE 4.6 CATEGORIES SORTED IN SUB-SORTS

Subsort of (15) other metal

- aluminum beverage refundable
- aluminum beverage non-refundable
- other aluminum
- steel beverage
- other ferrous
- non-ferrous
- other/multi-material

Subsort of (18) other Plastic

- PET beverage
- other PET
- HDPE (Rigid)
- LDPE (Rigid)
- PVC
- PS
- PP
- other plastic
- multi-resin/materials

Subsort of (22) wood

- other wood
- land clearing

Subsort of (29) Household Hazardous Wastes

- automotive supplies, including oil, and other products
- painting and decorating supplies,
- building and woodworking supplies,
- garden, pool and septic tank supplies,
- pet and hobby supplies,
- housecleaning and laundry supplies,
- medical supplies, and
- lead-acid batteries, dry cell batteries, by type, and including batteries which cannot easily be removed from the appliance in which they were purchased,
- aerosol,
- cosmetic, personal products;

TABLE 4.7 Example Data Sheets

WASTE SORTING DATA SHEET

Moisture sample numbers		Gross weight	Container	Net weight	Comments
	Paper				
	newspaper				
	cardboard				
	fine				
	glossy / telephone				
	packaging				
	tetra brik				
	non–packaging				
	other / multi–material				
	contaminated				
	Glass				
	beverage – refundable				
	beverage – nonrefundable				
	food				
	other				
	Metals				
	alum. bev. –refundable				
	alum. bev. – nonrefundable				
	other aluminum				
	steel beverage				
	other steel cans				
	other ferrous				
	non–ferrous				
	other / multi–material				

WASTE SORTING DATA SHEET

Moisture sample numbers		Gross weight	Container	Net weight	Comments
	Plastic				
	PET beverage (1)				
	other PET				
	HDPE (2) rigid				
	LDPE (4) rigid				
	HDPE (2) film				
	LDPE (4) film				
	PVC (3)				
	PS				
	PP (5)				
	other plastics				
	multi-resin, multi-material				
	Leather				
	Rubber				
	used tires				
	other				
	Organic				
	kitchen - animal				
	kitchen - vegetable				
	yard waste				
	landscaping				
	wood				
	Brown Goods				

WASTE SORTING DATA SHEET

Moisture sample numbers

		Gross weight	Container	Net weight	Comments
	Textiles				
	natural				
	synthetic				
	Construction/Demolition				
	Residue				
	Household Hazardous Wastes				
	automotive				
	paint / decorating				
	building / woodworking				
	garden / pool / septic tank				
	pet / hobby				
	house cleaning / laundry				
	medical				
	aerosol				
	cosmetics / personal products				
	batteries – lead acid				
	batteries – dry cell				
	Other				

TOTAL BEFORE SORTING	GROSS	CONTAINER	NET
TOTAL AFTER SORTING	NET		
LOSS	NET		

TABLE 4.8 METHODS FOR IDENTIFYING RIGID PLASTIC

	Type of Plastic					
	HDPE	PET	PVC	P/P	LDPE	P/S
Weight % of bottles produced (1986) in U.S.A.	62%	24%	7%	3%	1%	Nil
Float/sinks in water	F	S	S	F	F	S
Can be transparent	NO	YES	YES	YES	NO	YES
Burns with matches	YES (White Smoke, Drips)	YES (Drips)	NO	YES (White Smoke, Drips)	YES (White Smoke, Drips)	YES (Black particles, No Drips)
Rigidity	Semi-Rigid	Rigid, Tough	Semi-Rigid	Semi-Rigid	Flexible	Brittle to Semi-Rigid
Bottle surface	Rough	Usually Glossy	Very Glossy	Usually Low Gloss	Low Gloss	Glossy

Table 4.9 contains a list of common items found in the waste stream for each type of plastic. Code labels are very helpful, but are presently found on only about 50% of the rigid plastic. Once an item is tested and identified, it is added to the list to avoid duplicating the test.

After sorting, the little bits that remain on the table are grouped into the residue category as "fines". It is usually possible to keep these fines down to less than 3% of the total sorted weight.

Once the sample is sorted, and the plastics, metals and hazardous wastes are sorted, the categories are ready to be weighed (Photo 13).

It is recommended that several scales be used to weigh the components. Low weight items, such as plastics, need greater precision than heavy weight items. Therefore, 2 kg, 12 kg and 50 kg scales are suggested for weighing of the components.

4.6 VOLUMES

The volume of waste is difficult to quantify since it changes.

Waste has the greatest volume when it has first been discarded. This volume reduces during collection and disposal.

The goal of this survey is to estimate the volumes of waste as it arrives at the disposal site. This is done by establishing waste densities which can convert weights into volumes.

Densities of paper products, plastics, metals, glass and organics are estimated by filling the sorted components into 70 litre garbage cans. The volume of each category is recorded. The densities of each of the five major categories are calculated using the weights of the components.

An average of the density values can be used to convert the waste stream percentages by weight into volume estimates.

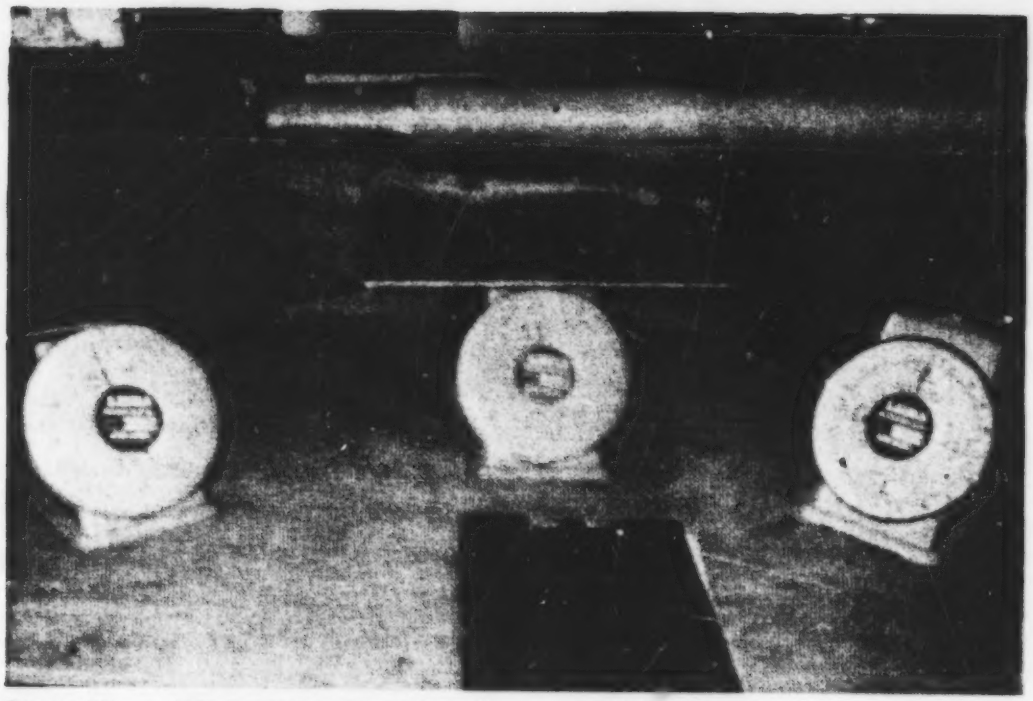


Photo 13 **The sorted waste categories are weighed and their weights are recorded.**

Photo 14 **Samples are obtained from waste categories for moisture content analysis.**

TABLE 4.9 LIST OF COMMON ITEMS FOUND IN B.C. FOR VARIOUS TYPES OF PLASTIC

PET Polyethylene Terephthalete (code 1)

- mini and mickey liquor bottles
- mouthwash
- soft drinks (1 and 2 litre bottles)

HDPE High Density Polyethylene (code 2)

- milk jug (4 litre)
- ice cream bucket (4 litre)
- Tylenol pill bottle
- purified drinking water jug (4 litre)
- motor oil (1 litre)
- margarine tubs
- laundry detergent
- dish soap
- fabric softener bottle
- bleach bottle
- cooking oil (4 litre)
- chip dip

LDPE Low Density Polyethylene (code 4)

- flexible lids

PVC Polyvinyl Chloride (code 3)

- barbecue sauce
- cooking oil
- plumbing pipe
- baby powder

PS Polystyrene (code 6)

- foam meat trays
- foam cups and tops
- asprin bottle
- foam hamburger container
- cookie trays
- bread tags
- green flower pots

PP Polypropylene (code 5)

- syrup bottle
- margarine tub
- baby food container bottom
- soya sauce bottle
- cottage cheese tub
- yogurt tub
- cream cheese tub
- cake frosting tub

Other (code 7)

- Heinz Ketchup bottle
- Le-Menu food tray

4.7 MOISTURE CONTENT SAMPLES

After the categories have been weighed, obtain samples for moisture content analysis (Photo 14). The need for moisture content analysis is discussed in Section 3.5. Not all of the waste categories need to be sampled. Those which should be sampled are: all nine types of paper products; glass containers; steel cans; aluminum other; HDPE or LDPE film; rigid plastics; kitchen waste of animal and vegetable origin; yard waste; combined textiles and residue.

The size of the sample to take depends on the size of the drying oven available. This should be established with the lab as described in Section 3.5. When taking moisture samples, it is important to be representative of the total sorted category. This requires that little pieces of all items in the category be placed in the moisture content sample. The larger the sample, the larger the pieces that can go into the sample. The samples should be sealed such that no moisture will be gained or lost during transport.

Photo 15 **Cat shovel (approximately 3 yd^3) contains the sorted 300 lb sample for return to the landfill face. The box contains the samples prepared for moisture content analysis.**

5.0 DATA ANALYSIS

The steps involved in data analysis are:

- to input wet weight data,
- to calculate the percent composition on a wet weight basis,
- to input moisture content values,
- to convert wet weights into dry weights, and
- to calculate percent composition on a dry weight basis.

These steps are described in detail in the following sections.

5.1 INPUT DATA

The wet weights of the objects separated and identified (called large objects), the sorted component weights, and the total weight of the waste whose composition is estimated (called the load weight) are input into a spread sheet. An example spread sheet created using Lotus 123 using values from the November sampling period in Castlegar (Gartner Lee, 1991) is presented in Table 5.1. Totals of the large objects and the sorted component weights are calculated as 713.6 and 141.37 kg respectively.

5.2 WET WEIGHT PERCENT COMPOSITION

The wet weight percent composition of each component is estimated for the entire load to be:

$$p_i = \frac{w_i/w_t * (D - L_t) + L_i}{D} \qquad (1)$$

Where:

- p_i is the percent of component i,
- w_i is the weight of component i,
- w_t is the total weight of all components,
- D is the load weight,
- L_i is the weight of large objects of component i, and
- L_t is the total weight of all large objects of all components.

TABLE 5.1 SAMPLE SPREADSHEET FOR DATA ANALYSIS

1. Castlegar (November)	RESIDENTIAL / COMMERCIAL						
LOAD I.D.: M1	WET WEIGHTS				DRY WEIGHTS		
LOAD WEIGHT (KG): 5500 Wet 3588 Dry	Large Objects (kg)	Sorted Weights (kg)	% Composition	Moisture Content (%)	Large Objects (kg)	Sorted Weights (kg)	% Composition
Paper (total)	**323.9**	**61.35**	**43.65%**	**40.8**	**164.9**	**37.13**	**40.24%**
newspaper	5.3	8.17	5.13%	36.4	3.4	5.20	5.08%
cardboard	318.6	26.68	22.22%	49.3	161.5	13.53	17.49%
fine		1.11	0.68%	14.2		0.95	0.91%
glossy / telephone		1.03	0.63%	18.7		0.83	0.80%
packaging		5.37	3.31%	31.3		3.69	3.54%
tetra brik		0.22	0.13%	19.0		0.17	0.17%
non-packaging		12.52	7.71%	34.2		8.24	7.91%
other / multi-material		2.93	1.80%	30.0		2.05	1.97%
contaminated		3.33	2.05%	25.9		2.47	2.37%
Glass (total)	**36.3**	**5.65**	**4.14%**	**1.8**	**35.9**	**5.54**	**6.32%**
beverage - refundable		2.07	1.27%	1.8		2.03	1.95%
beverage - nonrefundable		0.91	0.56%	1.8		0.89	0.86%
food		1.01	0.62%	4.0		0.97	0.93%
other	36.3	1.66	1.68%	1.0	35.9	1.64	2.58%
Metals (total)	**46.1**	**8.58**	**6.12%**	**4.9**	**45.6**	**8.10**	**9.05%**
alum. bev. - refundable		0.43	0.26%	5.2		0.41	0.39%
alum. bev. - nonrefundable		0.13	0.08%	5.2		0.12	0.12%
other aluminum		0.34	0.21%	14.0		0.29	0.28%
steel beverage			0.00%	2.9			0.00%
other steel cans		4.32	2.66%	6.9		4.02	3.86%
other ferrous	46.1	2.77	2.54%	1.0	45.6	2.74	3.91%
non-ferrous		0.17	0.10%	1.0		0.17	0.16%
other / multi-material		0.42	0.26%	17.6		0.34	0.33%
Plastic (total)	**36.3**	**17.19**	**11.24%**	**15.1**	**30.8**	**13.04**	**13.37%**
PET beverage (1)		0.98	0.60%	6.8		0.91	0.87%
other PET			0.00%	6.8			0.00%
HDPE (2) rigid		0.71	0.44%	6.8		0.66	0.64%
LDPE (4) rigid		0.58	0.35%	6.8		0.54	0.52%
HDPE (2) film		5.12	3.15%	31.1		3.53	3.39%
LDPE (4) film		5.01	3.08%	31.1		3.45	3.31%
PVC (3)			0.00%	6.8			0.00%
PS (6)		1.91	1.17%	15.8		1.60	1.54%
PP (5)		0.74	0.46%	6.8		0.69	0.66%
other plastics (7)		0.29	0.18%	6.8		0.27	0.26%
multi-resin / material		1.86	1.15%	25.7		1.38	1.33%
Leather			**0.00%**	**5.0**			**0.00%**
Rubber (total)		**0.74**	**0.46%**	**3.5**		**0.72**	**0.69%**
used tires			0.00%	1.0			0.00%
other		0.74	0.46%	3.5		0.72	0.69%
Organic (total)	**168.7**	**32.78**	**23.25%**	**49.0**	**128.5**	**15.48**	**18.44%**
kitchen - animal		4.24	2.61%	46.3		2.28	2.19%
kitchen - vegetable	44.9	25.47	16.49%	58.9	18.5	10.47	10.56%
yard waste			0.00%	52.2			0.00%
landscaping			0.00%	15.0			0.00%
wood	123.8	3.07	4.14%	11.1	110.1	2.73	5.69%
Textiles (total)	**4.2**	**2.13**	**1.39%**	**19.9**	**3.4**	**1.71**	**1.73%**
natural		1.84	1.13%	19.9		1.47	1.42%
synthetic		0.29	0.18%	19.9		0.23	0.22%
Brown goods	**2.7**	**1.16**	**0.76%**	**1.0**	**2.7**	**1.15**	**1.18%**
Bulky goods	**59.6**		**1.08%**	**5.0**	**56.6**		**1.58%**
Construction, Demolition	**25.7**	**0.92**	**1.03%**	**15.0**	**21.8**	**0.78**	**1.36%**
Residue		**10.18**	**6.27%**	**47.8**		**5.31**	**5.10%**
Household Hazardous	**8.3**	**0.69**	**0.57%**		**8.3**	**0.69**	**0.89%**
Other	**1.8**		**0.03%**		**1.8**		**0.05%**
TOTALS	**713.6**	**141.37**	**100%**	**34.8**	**500.4**	**89.64**	**100%**

An example of this calculation for total paper products is:

$$\frac{61.35/141.37 * (5500 - 713.6) + 323.9}{5500} = 43.65\ \%$$

5.3 MOISTURE CONTENTS

The moisture content values obtained from lab analysis of samples of waste components are entered in the spreadsheet. These moisture content values are used to convert wet weights to dry weights for reasons outlined in Section 3.5. Not all of the waste categories are sampled for moisture contents. Those which should be sampled are: all nine types of paper products; other aluminum; multi-material metals; film plastics; rigid plastics; polystyrene; multi-material plastics; kitchen waste of animal and vegetable origin; yard waste; combined textiles and residue. These are components which are more frequently contaminated or are susceptible to weather conditions.

Moisture contents of the remaining categories are estimated as:

glass beverage	1.8%
glass container	4.0%
glass other	1.0%
aluminum beverage	11.1%
steel beverage	2.9%
other steel cans	8.9%
other ferrous	1.0%
non ferrous	1.0%
leather	5.0%
used tires	1.0%
other rubber	3.5%
landscaping	15.0%
wood	11.0%
brown goods	1.0%
bulky goods	5.0%
construction/demolition	15.0%
household hazardous	0%

The moisture content values for the totals of paper, glass, metals, rubber, organics and textiles are calculated as:

$$\%\ mc = \frac{\text{sum of } p_i * mc_i}{\text{sum of } p_i} \qquad (4)$$

An example of this calculation for total glass is:

$$1.8\% = \frac{(1.27*1.8 + 0.56*1.8 + 0.62*4\,0 + 1.68*1.0)}{4.14}$$

The total moisture content of the load is also calculated with the above equation. This calculation is shown:

$$35.8 = \frac{(43.65*40.8 + 4.14*1.8 + 6.12*4.9 + 11.24*24.2 + .46*3.5 + \ldots + 6.27*47.8)}{100}$$

As-generated weights may be preferred to dry weights, simply by preference or to compare to other as-generated results (e.g., Bird and Hale).

As-generated moisture content is the moisture content of a component in its natural state (i.e., as manufactured, produced, grown). Estimates of as-generated moisture contents (Vesilind and Rimer, 1981; Bird and Hale, 1979) are:

newspaper		6.0%
cardboard		5.8%
fine paper		4.6%
glossy/telephone		4.1%
packaging		6.1%
non-packaging		7.0%
leather		5.0%
rubber		1.2%
other paper		7.0%
all glass		0.0%
all metals		0.0%
plastics		2.0%
Kitchen wastes	- animal	38.7%
	- vegetable	78.3%
yard wastes	- leaves	10.0%
	- grass	75.2%
	- evergreen	69.0%
wood		15.0%
textiles		7.0%

5.4 DRY WEIGHT PERCENT COMPOSITION

The first step of calculating the percent compositions on a dry weight basis is to convert wet weights of the large objects and sorted components into dry weights. Dry weights are calculated as:

$$\text{dry } w_i = \text{wet } w_i * (1 - mc_i/100) \quad (2)$$

and

$$\text{dry } L_i = \text{wet } L_i * (1 - mc_i/100) \quad (3)$$

Where mci is the percent moisture content of component i.

An example of this calculation using newspaper is:

3.4 = 5.3 * (1 - 5.13/100) for large objects and
5.20 = 8.17 * (1 - 5.13/100) for the sorted components.

The dry load weight is calculated using the total moisture content as in Equation (2). Finally, using dry weights, the dry percent composition is calculated using Equation (1).

Report Prepared By

Claudia R. Kauffman, M.A.Sc.
Environmental Engineer

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